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The Uncertainty Channel of Contagion

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The Uncertainty Channel of Contagion*

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Abstract

This paper analyzes the impact of uncertainty on the spread of stock market crises, both theoretically and empirically. The effect of uncertainty about the fundamentals on investment decisions is an important cause of financial crises propagating across countries. Firstly, a coordination game on investment illustrates the increasing effect of a surprise crisis in one country on the probability of a crisis in a second country through higher uncertainty there. An anticipated initial crisis generates the opposite effect. Secondly, these theoretical predictions are tested empirically. Fixed effects panel estimations validate the impact of the initial crisis on uncertainty in potentially-affected countries. Subsequently, probit estimations confirm the positive impact of uncertainty on the crisis probability in the affected economy. The results are robust across various specifications.

JEL classification: C 72, D 82, D 84, F 21, F 32, F 34, F 41

Keywords: Capital Flows, Government debt, Sudden Stops, Global Games, Coordination Failure

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1 Introduction

Financial crises in emerging markets in recent years have been especially centered around the Mexican (December 1994), the Thai (July 1997), and the Russian (August 1998) crises. Financial markets witnessed a similar accumulation of crises in developed countries in the context of the crisis of the European Exchange Rate Mechanism (September 1992).[1] These periods of crises concentration suggest contagion effects across countries.

Because of the high costs of these financial crises in emerging markets, researchers and practitioners have been exploring these cases. Specifically under investigation are the mechanisms through which crises spread, the factors that render countries vulnerable to contagion, and, most importantly, which policies might help prevent contagion.

This paper addresses these questions by analyzing one particular mechanism of the spread of crises: the contagion of crisis through uncertainty about the fundamentals. Recall that in the present study the term *uncertainty* describes the dispersion of private opinions of investors on the state of the fundamentals in a particular country. The present paper focuses on financial crises characterized by a severe plunge in stock market returns. *Contagion* is defined as the propagation of crises across countries beyond what would be implied by common shocks.[2]

It can be observed that, after a number of crises, the disagreement about the fundamentals in other markets – especially those markets that are later on themselves hit by a crisis – increases. Figure 1 illustrates this observation in the case of the Thai crisis in 1997.[3] As illustrated in the graph, the uncertainty not only increases in Thailand after the crisis, but also in neighboring countries. Korea, for example, is characterized in the data by a build-up of uncertainty after the Thai crisis. Korea is then hit by a currency crisis in November 1997. In addition, Figure 1 shows that the crisis in Thailand does not have an effect on the degree of uncertainty in Taiwan and the UK, neither were these countries economically strongly affected by the crisis.

However, in the case of other financial crises, careful scrutiny reveals that uncertainty about the fundamentals decreases in other markets after the crisis in the initial market. For example, this is the case in the period around the Argentinean crisis in 2002, which is illustrated in Figure 2.

The recent literature distinguishes between surprise crises as, for example, the Thai crisis in 1997 and anticipated crises as, for example, the Argentinean crisis in 2001/2002.

[1]See, for example, Broner, Gelos, and Reinhart (2006), Caramazza, Ricci, and R. (2004), or Kaminsky, Reinhart, and Vegh (2000) for the dates of the crises.

[2]See Didier, Mauro, and Schmukler (2006) for this definition. Henceforth, I will use the terms *contagion*, *spread*, *transmission*, and *propagation* of crises interchangeably.

[3]The left Y-axis displays the crisis variable. The two bars in the figure show the two most pronounced crisis events in the Thai crisis: First, the severe devaluation of the Bath in the beginning of July 1997 and second, the substantial drop in stock market returns one month later. The dates are chosen in accordance with Kaminsky et al. (2000) and Goldstein (1998). The right Y-axis displays the uncertainty about the fundamentals in the tracked economies. Uncertainty is measured by the standard deviation of growth forecasts for the current and following year, by financial analysts within the tracked countries. For more details on this measure, please refer to Appendix 6.

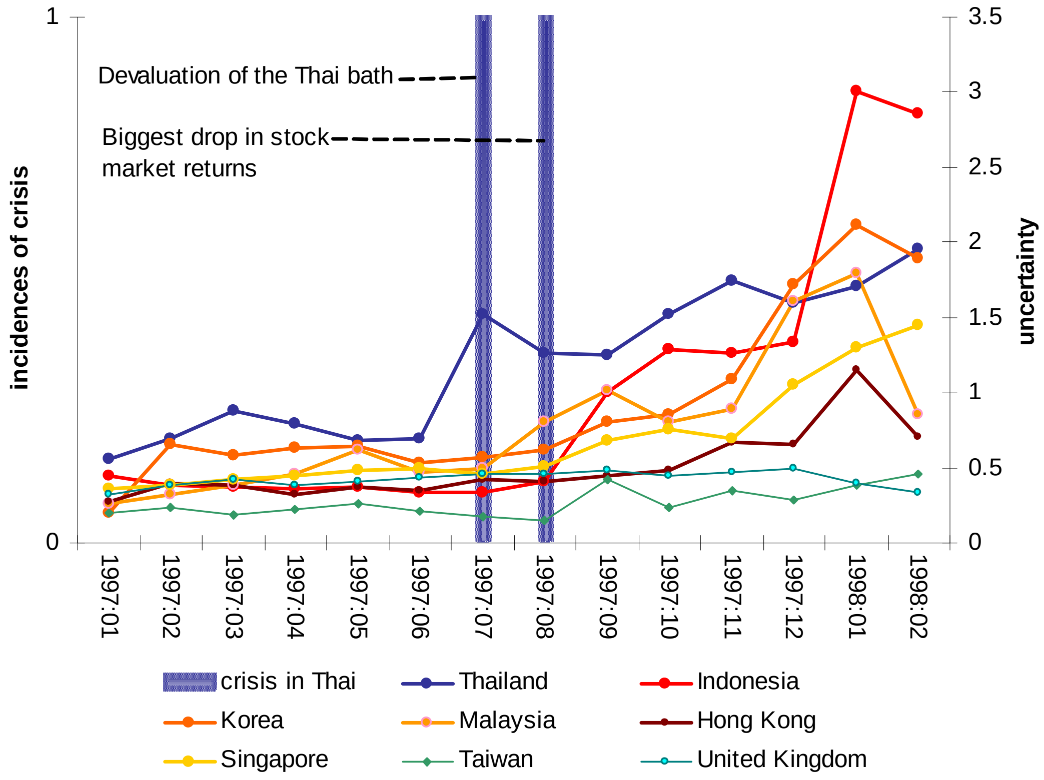

Figure 1: Uncertainty in the surroundings of the Thai crisis

This literature argues that the international repercussions of the anticipated crises in Brazil (January 1999), Turkey (February 2001), and Argentina (December 2001) were much less important than those after the crises in Mexico (December 1994), Thailand (August 1997), and Russia (August 1998).[4]

This paper picks up this distinction and shows that surprise crises increase uncertainty about fundamentals in other countries, thereby resulting in a higher probability of crises there. In contrast, the occurrence of anticipated crises decreases disagreement about the state of the fundamentals in other countries, thereby lowering the probability of a crisis there.

The present analysis contributes to the literature in two ways: First, uncertainty about the fundamentals is theoretically illustrated as a factor transmitting crises across markets. Second, predictions of the theoretical model are validated empirically. The role of uncertainty about the fundamentals has been neglected in the existing literature on contagion. So far, common investors have been detected as the main reason of the spread of financial crises between economies. While early research focused on trade linkages[5] and on macroeconomic similarities between economies[6], more recent analyses converge to the view that common creditors are at the core of contagion. This view is supported by a large number of empirical

[4]See Kaminsky et al. (2000) or Didier et al. (2006)

[5]See, for example, Gerlach and Smets (1996).

[6]See, for example, Goldstein (1998).

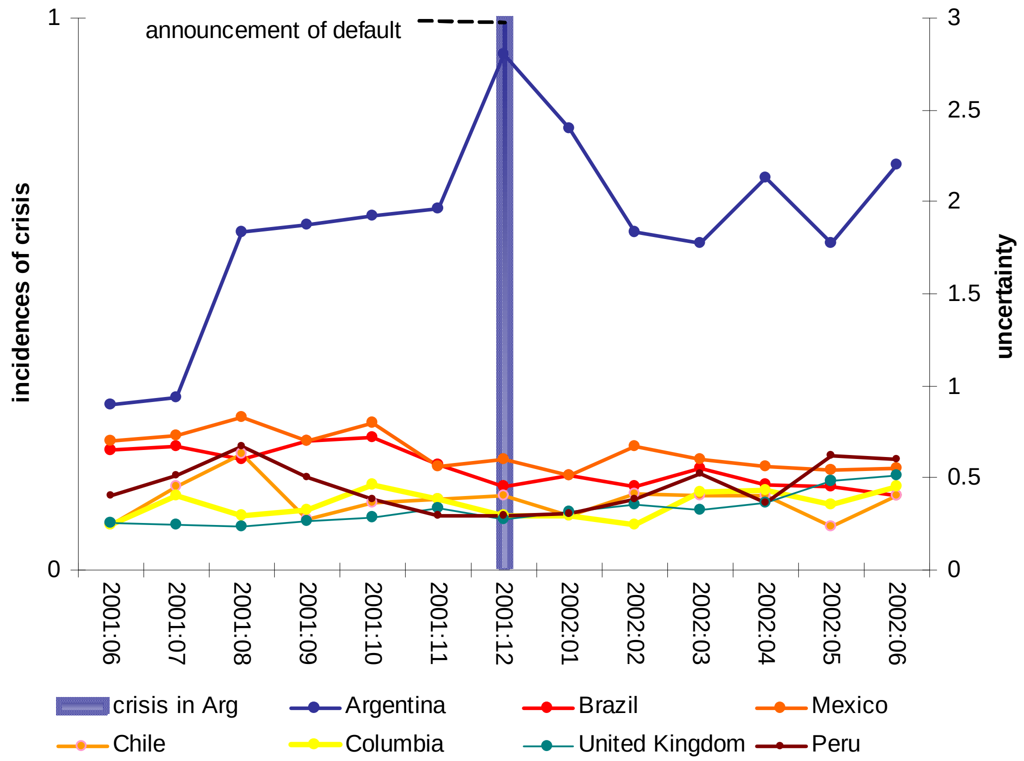

Figure 2: Uncertainty in the surroundings of the Argentinean crisis

analyses.[7]

Based on the insight into the role of common investors, the theoretical literature suggests different propagation mechanisms. Research thus far examines herding due to fixed information cost[8], differently informed investors[9], changes in investors' risk aversion[10], and wealth effects[11] as possible propagation channels for crises.

Following Goldstein and Pauzner (2004), I model the financial crisis in country B as a coordination game between private investors. The reason for using a coordination game is that the set up of a coordination game is well suited to analyze the effect of uncertainty about the fundamentals. The present model differs from the Goldstein and Pauzner (2004) set up in two crucial ways. The first difference concerns modeling the initial-crisis country and the potentially-affected subsequent country. While Goldstein and Pauzner (2004) explicitly model the sequence of two bank-run crises of the Diamond and Dybvig (1983) type, I focus on the second economy exclusively. I model the occurrence of a crisis in the second country, assuming that either a surprise crisis takes place in the first country or an anticipated crisis.

The second difference concerns the mechanism through which the crisis spreads. In Goldstein and Pauzner (2004), the crisis spreads due to a wealth effect. In my set up, the

[7]See, for example, Van Rijckeghem and Weder (2001) and Caramazza et al. (2004).
[8]See Calvo and Mendoza (2000).
[9]See Kodres and Pritsker (2002).
[10]See Broner et al. (2006).
[11]See Goldstein and Pauzner (2004).

change in uncertainty about the fundamentals transmits the crisis. I assume that uncertainty about the fundamentals increases in the second country if a surprise crisis hits the first country. Further, I assume that uncertainty decreases if an anticipated crisis occurs in the first country. The illustrative model in this paper is then used to show that an increase in uncertainty increases the probability of a crisis in the second country while a decrease in uncertainty makes a crisis less likely there.

This study offers two justifications of the assumption that a surprise crisis in an initial-crisis country increases the uncertainty in another country: The first justification is the empirical evidence presented in Figures 1 and 2. The second justification is the following line of arguments: If a crisis hits a country by surprise, i.e., without investors expecting the event, investors learn that they did not put sufficient effort into information processing given existing data-processing technology. If they want to predict crises in other countries, they have to increase their investment in information processing. However, a number of the investors realizes losses in the first country and, hence, are less inclined to invest in the second economy.[12] Given the assumption that the payoff of one agent positively depends on the fraction of other agents investing, i.e., that strategic complementarity prevails between investments, this leads to all agents optimally choosing to spend less on their information processing after the crisis in the first country.[13] As a result, all agents receive more dispersed signals about the true value of the fundamentals.

This mechanism about how the degree of uncertainty depends on a crisis in a first country works in the opposite direction if an anticipated crisis materializes. In this case, investors' trust in their information processing is strengthened and they are willing to spend a higher amount on gathering information, despite the crisis in the first market. This higher effort in information processing, in turn, leads to more precise signals.

The present model illustrates the presence of contagion in a coordination game: In country B, infinitely many investors (agents) have one unit of endowment available for investment there. If they choose not to invest, they receive a certain return of zero. In case that they invest, the return depends positively on the fraction of other agents who invest. In addition, the return decreases with an increasing level of the fundamentals. A high level of fundamentals indicates high costs of investing (this could be due to high political instability or high transaction costs). The fundamentals of the economy are uniformly distributed over a finite support. However, investors cannot observe the true realization of the fundamentals but receive a private signal that is symmetrically and uniformly distributed around the realization of the true fundamentals.[14] This means that investors base their investment decisions on the expected return, given their private evaluation of the fundamentals.

This information structure yields a threshold equilibrium in terms of the fundamentals in B and the outcomes in A. Below the threshold, the investors coordinate on investing; above,

[12]This is an outcome of the model by Goldstein and Pauzner (2004).

[13]The assumption of strategic complementarity is common in the global game literature.

[14]This assumption was first introduced by Carlsson and van Damme (1993) who developed the technique of global games, which was then applied, for example, to self-fulfilling currency crises in Morris and Shin (1998).

no one invests. Comparative static analysis shows that the threshold is a decreasing function of the dispersion of the private signals. The dependence of the uncertainty in B on the crisis in A together with the result of the comparative static analysis of the threshold in B are sufficient to illustrate the existence of contagion: A surprise crisis in country A increases the dispersion of the private signals, i.e., the support of the private signals around the true value of the fundamentals, in B and hence, decreases the threshold there. The decrease in the threshold means that coordination on the bad equilibrium becomes more likely, i.e., a crisis becomes more probable. In the case of an anticipated crisis in country A, the opposite is true.

To validate empirically the uncertainty channel of contagion, I construct a rich data set for 38 countries with monthly time series (December 1993 to September 2005). This country sample and the associated time frame enables the inclusion of the following six pronounced crisis periods into the analysis: Mexico (1994), Thailand (1997), Russia (1998), Brazil (1999), Turkey (2001) and Argentina (2001). The two main variables in the data set are a stock market crisis dummy and an uncertainty measure. A stock market crisis is detected by significant negative variation in stock market returns. The monthly stock market returns that serve as a basis for the crisis dummy are computed from the IFC (International Finance Corporation) investable US dollar total return index.[15] When necessary, I complete the returns with data from MSCI (Morgan Stanley Capital International) or national sources. The measure of uncertainty is the standard deviation of GDP growth forecasts between country experts. Additionally, I employ a large set of domestic control variables and alternative channels of contagion.

I proceed in two distinct steps. Firstly, I use fixed-effects panel estimations to establish the link from the initial crisis in country A to the uncertainty in other countries B. I control for country and time effects, running various robustness checks. Secondly, I quantify the effect of uncertainty in those economies on the probability of a crisis there. For this second step, I employ pooled probit estimation, controlling for country and time effects. Again, I control for potential domestic drivers of crises. Finally, as a check for alternative channels of contagion, I control for contagion through common creditors, trade links, the size effect of the initial stock market, and for overexposed common fund investors.

The empirical analysis in this paper expands the existing empirical literature on the spread of crises in several respects. First, the effect of uncertainty in the context of the spread of crises has been neglected so far. Second, as the panel data spans a larger time horizon, I can consider a larger number of crises periods.[16] Third, I control for a large number of alternative contagion channels, adapting them to the particular kind of crises analyzed – namely, substantial stock market drops. Fourth, including control for time effects results in very strict tests for the transmission channels of crises. The time-effects control takes

[15]The investable indices take into consideration restrictions on foreign investment. Therefore, this measure represents the part of the national stock markets accessible to foreign investors, which is relevant in the context of contagion.

[16]For example, Van Rijckeghem and Weder (2001) only consider the Mexican, Thai, and Russian crises, while Broner et al. (2006) analyze the Thai, Russian, and Brazilian crises.

care of all effects present at a particular point in time. In case of all emerging markets, the time-effects control for increases in the interest rates in the financial centers. Not all of the alternative contagion channels controlled for remain significant when controlling for time effects.

The analysis yields two main empirical findings. The first finding is that uncertainty about the fundamentals is a propagation mechanism of contagion, if the first country is hit by a surprise crisis. The first step of the analysis finds that the Mexican, Thai, and Russian crises increase the uncertainty in potentially-affected countries. The effect is stronger within the region where the crises occur; the effect appears more pronounced in countries nearer to the initial crises country. The second step of the analysis finds that the effect of uncertainty on crisis probability in countries B is positive, significant, and, as shown by marginal effects, not negligible in size.

The second finding is that in the case of an anticipated crisis, uncertainty about the fundamentals in the second economy is decreased, which, in turn, decreases the probability of a crisis there. The first step of the analysis yields the following result: The Brazilian, Turkish, and Argentinean crises decrease the uncertainty in the potentially-affected countries. The effect is stronger within the region where the crises occur and in countries closer to the initial-crisis country. The second step of the analysis confirms that the effect of uncertainty in the potentially-affected countries on the probability of a crisis there is positive, significant, and not negligible.

These findings have several implications. The first, obvious implication is that a close monitoring of the fundamentals in the resident country and also of other countries is crucial. Particularly other countries in the first-country region and geographically close ones should be focused on. Surprise crises seem to be especially bad because they set off mechanisms that further worsen the situation. This paper illustrates such a mechanism through the uncertainty about the fundamentals. The second implication is that, once a surprise crisis has hit a first country, policy makers in potentially-affected countries should move toward policies that diminish the potential increase in uncertainty. One venue could be to develop mechanisms for such situations through which governments could credibly disseminate very precise information about the state of their economy so that the private signals get as precise as possible. One could even start to think about subsidies for information-gathering technology.

The paper is organized as follows. In section 2, I describe the model. In section 3, I present the empirical analysis. Section 4 explains policy implications while section 5 contains the conclusion.

2 The Model

This section presents a simple coordination game to illustrate the occurrence of contagion between two markets that are uncorrelated in terms of their fundamentals. The focus of the model is on the potentially-affected country. In an investment game, I illustrate that a crisis in country B becomes more probable after a surprise crisis in country A and becomes less probable after an anticipated crisis materializes in a first country. The transmission functions through the uncertainty about the fundamentals. For the theoretical illustration of this channel, three ingredients are necessary. A first ingredient is that the dispersion of private signals in country B increases due to a surprise crisis in country A and, conversely, that dispersion of private signals decreases due to an anticipated crisis in country A. In this study this effect of a crisis on uncertainty about the fundamentals is introduced as an assumption.[17]

The second ingredient is a unique threshold equilibrium in terms of the fundamentals of the economy, so that it is possible to attribute to each level of the fundamentals the realization of the investment or the non-investment equilibrium. Once this unique threshold equilibrium is determined, the third ingredient is the comparative static analysis of the threshold equilibrium with respect to the uncertainty about the fundamentals. If the threshold shifts with changes of the uncertainty, contagion is present.

The assumption that a surprise crisis in an initial-crisis country increases uncertainty about the fundamentals in another country can be justified by the empirical evidence presented in the introduction. Additionally, it could be argued that investors learn after a surprise crisis that they did not put sufficient effort into information processing, given existing data-processing technology. If investors want to predict crises in other countries, they must increase investment in information processing. However, a number of the investors realize losses in the first country and, hence, are less inclined to invest in the second economy.[18] Given the assumption that the payoff of one investor depends positively on the fraction of other agents investing, i.e., that strategic complementarity prevails between investments, this leads to all investors choosing optimally to spend less on information processing after the crisis in the first country.[19] As a result, all investors receive more dispersed signals about the true value of the fundamentals. The mechanism works in the opposite direction if an anticipated crisis materializes in the initial-crisis country. In this case, investor trust in information processing is strengthened. Therefore, investors are willing to spend a higher amount on gathering information despite the crisis in the first market. This in turn leads to more precise signals.

The notion of a surprise crisis and an anticipated crisis in the first crisis country are absent in the setting of Goldstein and Pauzner (2004). However, the idea of the distinction between surprise crises and anticipated crises is consistent with the set up of a global game. Think of a surprise crisis in the following way: If the prior expectation about the value of the true fundamentals is lower than the threshold equilibrium, investors, on average, expect that no crisis will happen. If the fundamentals are then realized in the range above the threshold, this realization can be interpreted as a surprise crisis. On the other hand, if the prior expectation about the value of the true fundamentals is higher than the threshold

[17] It is an interesting topic for future research to explicitly model this effect.

[18] This is an outcome of the model by Goldstein and Pauzner (2004).

[19] The assumption of strategic complementarity is common in the global game literature.

equilibrium, investors expect the bad equilibrium to be realized. If is the bad equilibrium is then realized, this can be interpreted as an anticipated crisis.

2.1 Model Set Up

Here, I describe the game in country B taking as a given the outcomes in the initial crises country A.[20]

The realizations of the investment environment are assumed to be uniformly distributed over the finite interval $\theta \sim [\breve{\theta}, \hat{\theta}]$. A high value of the fundamentals θ signifies an adverse environment for investment with high investment obstacles.

There is a continuum of $[0, 1]$ identical investors . Each investor decides whether to invest 1 unit or not. If an investor does not invest, he receives a certain return of 0. If he decides to invest, he receives an uncertain return of $P(\theta, \pi^{-i})$, which depends negatively on the level of fundamentals θ and positively on the fraction of other investors that invest in B, π^{-i}. A strategy is defined as $\pi^i : [\breve{\theta}, \hat{\theta}] \to [0, 1]$, which means that investor i invests in state θ with probability $\pi^i(\theta)$. Due to the mass of agents being 1, the fraction of agents who invest at a particular state of fundamentals can be expressed as $\int_0^1 \pi^j(\theta)dj = \pi^{-i}(\theta)$ for $j \neq i$. The positive dependence on the fraction of other agents investing, i.e., strategic complementarity between the agents, can be explained by increasing returns on aggregate investment. These assumptions are reflected by the following payoff function of investor i:

$$P = R\pi^{-i}(\theta) - \frac{1}{2}\theta^2 \tag{1}$$

in which $R\pi^{-i}(\theta)$ stands for the simplest form of a return that is positively dependent on the fraction of other agents investing. Further, the last term can be interpreted as a cost of investing that increases exponentially with the worsening of the investment environment.

An investor decides whether to invest or not to invest in a country after receiving information about the fundamentals of the country. Assuming that the fundamentals are not common knowledge, each investor privately interprets publicly available information. The investors thus act upon their private signals. The private signals are uniformly distributed in an η surrounding of the true fundamentals θ: $\theta^i \sim U[\theta - \eta, \theta + \eta]$. Now, the variance of the signals depends on the outcomes in country A. In the case of a surprise crisis in country A, the private signals are uniformly distributed in an $\eta + c$ surrounding of θ, with c being a small positive number. In case of an anticipated crisis in A, the private signals are uniformly distributed in an $\eta - d$ surrounding of θ, with d being a small positive number.

An investor is more likely to invest if 1) the obstacles to invest are lower and 2) if a large number of other investors invest in the same country. However, in line with global games literature, I assume that there are small ranges at the extremes of the support of the fundamentals where investors have dominant strategies. If the fundamentals are very

[20] The investment game in country B is a straight application of the theory of global games by Carlsson and van Damme (1993). Similar investment games have been used in the literature, for example, by Heinemann (2005).

good, i.e., if the investment obstacles are very low, it is optimal for an investor to invest irrespective of the actions of all the other investors. On the other extreme, if the state of the fundamentals is very adverse to investment, then it is the optimal strategy of an investor not to invest, irrespective of the actions of the other investors.

Formally, this assumption means that the support of the fundamentals has to exceed the border of the dominance region by at least 2η: $\breve{\theta} + 2\eta < \underline{\theta} < \overline{\theta} < \hat{\theta} - 2\eta$, in which $\underline{\theta}$ stands for the border of the lower dominance range and $\overline{\theta}$ stands for the border of the upper dominance range. This condition ensures that an investor is indifferent between investing and not investing at the borders of the dominance ranges. At the border of the dominance region at the high end of the support, the investor is indifferent, even if the fraction of other agents investing equals 1, $P(\overline{\theta}, 1) = 0$. At the border at the dominance region at the low end of the support, the investor is indifferent even if no one else invests, $P(\underline{\theta}, 0) = 0$. When an investor receives a signal $\theta^i < \underline{\theta} - \eta$, he knows that his payoff $P^i > 0$, no matter what all the other investors are doing. Therefore, he will invest. Analogously, if he receives a private signal $\theta^i > \overline{\theta} + \eta$, he knows that $P^i < 0$, no matter what all the other investors are doing. Therefore, he will not invest. In contrast, between the borders of the dominance regions, the payoff of an investor depends on the actions of other investors. This results in a tripartite partition of the fundamentals. Under common knowledge, multiple equilibria exist in this intermediate range of fundamentals. However, the assumption of private information eventually allows for finding a unique equilibrium. This is the purpose of the next section.

2.2 Solving the Model

Firstly, I will show that the game with private information is characterized by a unique Bayesian Nash equilibrium in country B.

Proving the existence and the uniqueness of the equilibrium requires several steps. In the first step, a simple switching strategy is assumed to be followed by all investors. In the second step, the monotonicity of the expected payoff difference in the private signal has to be proved. Based on this, dominated strategies can then be iteratively eliminated in the third step, beginning at borders of the dominance regions. Finally, it has to be shown that there is only one unique value of the level of debt, for which the payoff difference, given the private signal, equals zero. This level of debt is the threshold value, below which all agents invest and above which no one invests.

In the private information game, a strategy is a function of the private signal received instead of the true value of the fundamentals: $\pi^i(\theta^i) : [\breve{\theta}, \hat{theta}] \rightarrow [0, 1]$.[21] The payoff function of an investor now depends on his private signal on the state of the fundamentals and is therefore given by

$$P(\theta^i) = E[R\pi^{-i}(\theta^j) - \frac{1}{2}\theta^2|\theta^i] \tag{2}$$

[21] Note that the private signal is drawn from the same support as the true value of the fundamentals. No private signal will be realized at a level of debt that is, in reality, nonexistent. As noted earlier, the support of the true value of the fundamentals must exceed the borders of the dominance regions sufficiently, i.e., by 2η, so that there exist private signals that are consistent with those dominant strategies.

Analogously, the fraction of other agents investing $\pi^i(\theta^i)$ is a function of the private signals θ^j they receive.

In the first step towards the unique equilibrium, it is assumed that all investors follow a simple switching strategy. A switching strategy I_T means that an investor invests with probability one if, and only if, the signal it receives is below a threshold T and abstains from investing with probability one if the signal is above the threshold[22]

$$I_T = \begin{cases} 1 & \text{if } \theta^i < T \\ 0 & \text{if } \theta^i \geq T \end{cases} \tag{3}$$

The simple switching strategy permits rewriting the payoff function, replacing the fraction of other investors investing with the probability that one other investor receives a signal that is smaller than the threshold signal

$$\pi^{-i}(I_T) = \int_0^1 I_T(\theta^j)dj = prob(\theta^j \leq T) \tag{4}$$

$$P(\theta^i, I_T) = R \cdot 1 \cdot prob(\theta^j \leq T) + R \cdot 0 \cdot prob(\theta^j > T) - E(\frac{1}{2}\theta^2|\theta^i) \tag{5}$$

Recall that at the borders of the dominance regions, the investors are indifferent between investing and not investing.[23] If the payoff function is monotonically decreasing in the private signal, clearly, these borders are the lowest and the highest possible threshold signals for the switching strategies. In the dominance region at the low end of the support of the fundamentals, the investment obstacles are so low that the payoff of an investor is positive if investing, irrespective of the actions of all other investors. At the border itself an investor is, then, indifferent. In the dominance region at the high end of the support, the investment obstacles are so high that the payoff of an investor is positive if investing, irrespective of the actions of all other agents. In the case of a monotone payoff function, the borders of the dominance regions are, therefore, the starting points of the iterative elimination of dominated strategies.

Accordingly, in a second step towards the unique equilibrium, the monotonicity of the payoff function in the private signal has to be shown.

Lemma 1 *$P(\theta^i, I_T)$ is strictly monotonically decreasing in the private signal θ^i.*

Proof. See Appendix 6. ■

Due to the strict monotonicity of the payoff, the lowest possible threshold for a switching strategy of all the investors is $\underline{\theta}$. Similarly, the highest possible threshold is $\overline{\theta}$. For all $\theta^i < \underline{\theta}$, the payoff is positive, irrespective of the actions of all other investors. As the rationality of

[22]Continuity arguments show that such a simple switching strategy is optimal. Therefore, generality is not lost when imposing it in the first place.

[23]More precisely, each investor is indifferent at the border of the high dominance region, given that all other investors invest $P(\overline{\theta}, 1) = 0$ or at the border of the dominance region at the high end of the support, if no one else invests $P(\underline{\theta}, 0) = 0$.

the investors is common knowledge, not to invest is a dominated strategy for signals below $\underline{\theta}$. At the other extreme, for all signals $\theta^i > \overline{\theta}$, the payoff difference is negative.

Due to the strategic complementarity between investors, the worst scenario that an investor must consider is the case where $I_T = I_{\underline{\theta}}$. This case means that for all values of the fundamentals in the multiplicity range, investors choose not to invest although the fundamentals would, in case of coordination on the high growth equilibrium, also allow for this. The best scenario would be a switching strategy of $I_T = I_{\overline{\theta}}$.

At this point, it is possible to start the iterated elimination of dominated strategies. This iteration permits cutting the multiplicity range down to a unique threshold signal. The elimination functions as follows: If an investor i receives a signal that is very close to the border of the dominance region, the probability that other investors receive signals within the dominance region and, thus, have a dominant strategy is very high. Due to the strict monotonicity, this suffices to induce the investor i to have a dominant strategy as well. This is true for all the investors. Therefore, the range between the signal of investor i and the former border of the dominance region can be added to the dominance region. Performing this addition at both ends of the support and iterating this process leads to the maximum [minimum] signal at which investor i is indifferent between investing and not investing; this signal has to be, at the same time, the threshold of the switching strategy of all other investors.[24]

According to Milgrom and Roberts (1990), in all games with strategic complementarity the set of strategies that resist the iterative elimination of dominated strategies are limited by Nash equilibria. Nash equilibria are not eliminated through this process. Thus $I_{\underline{\theta}^\star}$ and $I_{\overline{\theta}^\star}$ are the most extreme Nash equilibria of the game. No Nash equilibrium exists below $\underline{\theta}^\star$ in which the investors do not invest. Likewise, no Nash equilibrium exists above $\overline{\theta}^\star$ in which the investors invest.

Steps one and two enable the third step in the proof of the uniqueness of the equilibrium. Given Lemma 1, it now suffices to show that equation

$$P(\theta^i = \theta^\star, I_{\theta^\star}) = Rprob(\theta^j \leq \theta^\star) - E(\frac{1}{2}\theta^2|\theta^i) = 0 \tag{6}$$

has a unique solution. This can be expressed in the following Lemma.

Lemma 2 *There exists only one value, for which the expected payoff equals* 0 *given that investor i receives exactly the threshold signal* $\theta^\star$ *as a private signal, and given that all other investors have a switching strategy, in which the switching signal equals exactly* $\theta^\star$.

Proof. See Appendix 6. ■

This unique solution is

$$\theta^\star = (R - \frac{1}{3}\eta^2)^{\frac{1}{2}} \tag{7}$$

The three steps can be summarized in the following proposition:

[24]For a more formal consideration of the iterative elimination, please see Appendix 6.

Proposition 1 *There exists a unique threshold equilibrium $\theta^\star$ of the game with imperfect information, such that any investor i invests if and only if $\theta^i \leq \theta^\star$ and does not invest if $\theta^i > \theta^\star$.*

Proposition 1 permits the conclusion that $\theta^\star$ identified by Equation (7) is the unique threshold equilibrium of the game with private information.

2.3 Results and Implications

The unique threshold equilibrium allows to show that an increase in the degree of disagreement about the fundamentals in country B increases the probability of a crisis there.

Proposition 2 *A crisis becomes more likely to occur in country B if a surprise crisis happens in country A. A crisis becomes less likely to occur in country B if an anticipated crisis materializes in country A.*

Proof. To prove Proposition 2, it suffices to calculate the comparative statics of the unique threshold equilibrium in terms of the fundamentals with respect to η.
These deliver the following result:

$$\frac{\partial \theta^\star}{\partial \eta} = \frac{1}{2}(R - \frac{1}{3}\eta^2)^{-\frac{1}{2}}(-\frac{2}{3}\eta) < 0 \tag{8}$$

This result implies that the threshold below which all investors invest shifts to the left (right), i.e., to better (worse) levels of the fundamentals, if the dispersion of private signals around the true value of the fundamentals increases (decreases) due to a surprise (anticipated) crises in country A. Thereby, the probability space of the good equilibrium is reduced (increased) and, hence, a crisis becomes more (less) likely in the case where private signals are dispersed in an $\eta + c$ ($\eta - d$) surrounding of the true fundamentals, as opposed to the case where they are only dispersed in an η surrounding. ■

Due to the assumption that higher uncertainty results from a crisis in another country, e.g., Thailand in the case of Korea, the shift of the threshold can be viewed as an incident of contagion.[25]

Figure 3 illustrates the comparative static analysis. The payoff is plotted against the level of the fundamentals. $\theta_B^{\star\prime}$ lies at lower levels of the fundamentals than $\theta_B^\star$ as described above due to $\eta + c$ being a higher value than η. Clearly, the threshold based on a dispersion of private signals $\eta - d$ would lie at higher levels of the fundamentals than $\theta_B^\star$.

2.4 Testable Hypotheses

In this section, the predictions of the theoretical model are translated into testable hypotheses. From Proposition 2, two testable hypotheses can be derived:

[25] This assumption is justified by empirical evidence, see Figure 1.

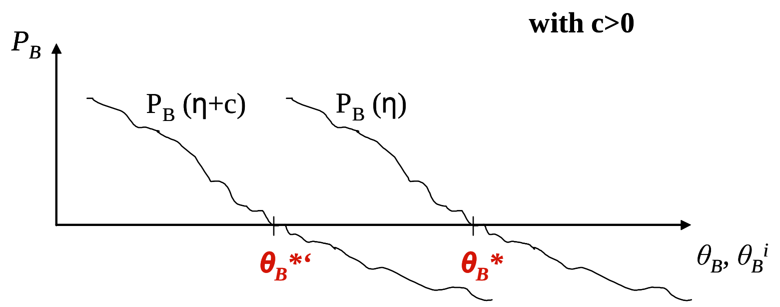

Figure 3: $\theta_B^\star$ as a function of the dispersion of private signals in country B

Hypothesis 1 *The occurrence of a surprise crisis in a first country makes a crisis in a second country more likely through an increase in uncertainty about the fundamentals in the second country.*

Hypothesis 2 *The occurrence of an anticipated crisis in a first country makes a crisis in a second country more likely through a decrease in uncertainty about the fundamentals in the second country.*

3 Empirical Analysis

The purpose of this section is to validate the predictions of the theoretical model. I focus on showing the effect of uncertainty about the fundamentals as a channel through which crises spread from one financial market to another.

3.1 The Data

A rich data set is used comprising monthly observations of different alternative crisis measures as the dependent variable, a measure of uncertainty as the main explanatory variable, and a large set of control variables.[26] The data run from December 1993 to September 2005. The sample comprises 38 countries – 15 developed and 23 emerging – where the selection of the period and countries reflects the existence of uncertainty and return data.[27] I exclude the initial crises countries (Argentina, Brazil, Mexico, Russia, Thailand, and Turkey) from the set of potentially-affected countries. Although this means a non-negligible loss in observations, this procedure is in favor of finding convincing results.

The explanatory variable that is most interesting for the current analysis is uncertainty about the fundamentals. I use the standard deviation of growth forecasts by a group of country experts as a measure of uncertainty. In models similar to Morris and Shin (1998), uncertainty takes the form of the dispersion of private signals around the true value of the fundamentals. In the current model, this is the dispersion of the private signals about the

[26]Please refer to Table 2 in Appendix 6 for detailed descriptions of the time series and their calculation.
[27]For details, please refer to Table 1 in Appendix 6.

true value of the investment environment. Such data is not directly observable. However, investment environments correlate strongly with the country levels of GDP and associated growth. Hence, the available data by Consensus Economics on the standard deviation of GDP growth forecasts between experts in an economy seems a reasonable proxy.[28]

To measure the significant drops in stock returns, a crisis dummy variable is constructed. Monthly stock market returns, computed from IFC (International Finance Corporation) investable US dollar total return index, serve as a basis for this crisis dummy.[29] When needed, I complete the returns with data from MSCI (Morgan Stanley Capital International) or national sources.[30] I construct a binary crisis variable of severe drops in stock market returns, in which a month is counted as a crisis month if the total return undershoots its sample mean by more than two standard deviations. After this initial drop, the subsequent months are also counted as crisis months until the return reverts into the one standard deviation band around the sample mean.[31]

I use a rich set of domestic control variables. Most important are the mean of the growth expectations by Consensus Economics to control for the status of the economy and its evaluation by investors. Additionally, I disentangle the effect of uncertainty about the fundamentals from effects linked to the volatility of stock market returns, which I include as a control variable into the regressions. Following Broner et al. (2006), I use the ICRG (International Country Risk Guide) indices of financial, economic, and political risk as a summary statistics to control for the state of the fundamentals in the potentially-affected country. Then, domestic liability dollarization, TOT growth, and credit growth are included as further control variables.

Numerous alternative mechanisms of contagion appear to be relevant in the context of stock market drops. Specifically, I control for contagion through common creditors. In line with Van Rijckeghem and Weder (2001), I use consolidated data of BIS banking statistics to construct an index of contagion through the presence of a common creditor. However, I construct a different index than their index. The index used in this paper reflects the dependence on common creditors as opposed to their measure that reflects the competition for funds. In the context of stock market drops, the dependence appears more relevant than competition for their funding.[32] Another relevant channel of contagion is trade with the crisis country. Following Glick and Rose (1999), I use bilateral export data from the IMF Direction of Trade Statistics to construct the measure of trade contagion. However, in

[28]Please refer to Koehler (2006) for detailed arguments why this measure is a good proxy of the dispersion of private signals around the true fundamentals of an economy. See Table 2 in Appendix 6 for a description of the exact construction of the variable. In the main analysis, I use a weighted average of current and following year forecasts as described in Table 2. However, as a robustness check I repeat all estimations with the current year, and all estimations with following-year forecasts, separately. The results are qualitatively the same and quantitatively similar.

[29]The investable indices take into consideration restrictions on foreign investment. Therefore, this measure represents the part of the national stock markets accessible to foreign investors, which is relevant in the context of contagion.

[30]For more details, please refer to Table 2 in Appendix 6.

[31]I run the regressions with variants of this measure, i.e., 1.5 standard deviations and also 3.

[32]For detail on the construction of this index, please refer to Table 2 in Appendix 6.

contrast to their contagion measure, I use the export share to country A in total exports. For the control of contagion through common overexposed fund investments, I use the index developed by Broner et al. (2006). I interact the alternative contagion measures with the crisis dummies for country A. It seems natural that the contagion variables only play a role for the uncertainty in country B if there is a crisis in country A to begin with.

3.2 Methodology

The goal of this study is to show that uncertainty about the fundamentals has a separate and non-negligible effect on the spread of crises apart from the channels already studied. If the goal of the present study were to prove the relevance of uncertainty and its predominant role relative to other potential explanatory variables in spreading financial crises, the best procedure to prove this point would be a two-step instrumental variable estimation.[33]

In the context of analyzing contagion, it would be difficult to find a valid instrument for the uncertainty in country B. Arguing, for example, for the use of the crisis in country A as an instrument for the uncertainty in B requires the crisis in A to significantly affect the uncertainty in B but not to directly affect the probability of a crisis in country B and not to affect it through a channel different from uncertainty. The existing literature on alternative channels of contagion already proves the last assumption wrong. Other variables linked to the crises in A, which might serve as instruments for the uncertainty in B, would have the same problem: they are likely to also feed into alternative channels of contagion.

Given the presence of alternative contagion channels other than the uncertainty channel and therefore the impossibility of finding a valid instrument for uncertainty in B, this empirical analysis is designed in the following way:[34] In a first step, the effect of the crisis in country A on the uncertainty in a second country B is estimated. To ensure that the effect of the crisis in A on the uncertainty in B is correctly quantified, I control for potential domestic drivers of uncertainty. I also control for country and time effects. Thereby, I employ a very strict test on the effect of uncertainty on the occurrence of a crisis. The control for time effects is often avoided in the literature. In the second step, I analyze the effect of uncertainty in country B on the probability of a crisis there. In this step, I run probit regressions estimating the effect of the uncertainty in B on the probability of crises there. I control for domestic factors that could trigger crises and also for alternative contagion channels. Additionally, I control for country and time effects.

One drawback of this approach is that in contrast to an instrumental variable estimation, reverse causality from the crisis in B on the uncertainty there cannot be entirely ruled out. However, as described in more detail in subsection 3.3.2, I run a number of regressions to be confident that this possibility is minimized in the chosen set up.

[33] A good example of a convincing instrumental variable estimation is Acemoglu, Johnson, and Robinson (2001) who analyze institutions as opposed to geography as explanation of differences in current dispersion of countries' incomes.

[34] In section 3.3.2, the reasons for this design are described in further detail.

3.2.1 Methodology Used to Estimate the Effect of the Initial Crisis on the Uncertainty in Potentially-affected Countries

To analyze the relevance of the uncertainty channel of contagion, I proceed in two distinct steps. In the first step, I pin down the effect of the crisis in country A on the uncertainty in a second country B. In the second step, I analyze the effect of uncertainty in country B on the probability of a crisis there.

In step one, I estimate two sets of regressions. Firstly, I specify the following test:

$$\begin{aligned} \text{unc}_{B,t} &= \alpha_0 \\ &+ \alpha_1 \text{d\_cr}_{Arg,t-1} + ... + \alpha_6 \text{d\_cr}_{Tur,t-1} \\ &+ \alpha_7 \text{d\_cr}_{B,t-1} + \alpha_8 \text{macrocntrls}_{B,t} + \delta_B + \varepsilon_{B,t} \end{aligned} \tag{9}$$

with $B = 1, 2, ..., 32; t = 1, 2, ..., 141$,

where $\text{unc}_{B,t}$ signifies the uncertainty in the potentially-affected country B at time t. I exclude the initial crises countries Argentina, Brazil, Mexico, Russia, Thailand, and Turkey in the panel as potentially-affected countries. Therefore, the index B represents the 32 remaining countries in the sample. $\text{d\_cr}_{A,t-1}$ signifies the lag of the crisis dummies in the initial-crisis countries A, representing Argentina, Brazil, Mexico, Russia, Thailand, and Turkey. The dummy variable takes a value of 1 if there is a significant drop in the stock market return. $\text{macrocntrls}_{B,t-1}$ stands for the set of domestic control variables described in section 3.1. δ_B stands for country specific effects. The level of uncertainty varies strongly across countries. Systematically, some countries are characterized by higher uncertainty than other countries, therefore, requiring control for country effects. I run fixed-effects regressions to accommodate this fact. Finally, $\varepsilon_{B,t}$ stands for the error term.

Controlling for time effects in the above setting is not possible because the average effect of each of the initial crises on the uncertainty in all the countries contained in the sample is estimated. As the coefficients for each of the crises are forced to be the same in the regression in all the potentially-affected countries, it could be that the coefficients of the time dummies capture part of the effect that actually comes from the crisis variable. To circumvent this problem, I interact the crisis variable with the distance between the crisis variable and the potentially-affected countries. I employ the distance variable first used by Rose (2004). This creates heterogeneity in the crisis variable across countries, which is necessary to be able to control for time effects.

Therefore, I run additional regressions based on the following equation:

$$\begin{aligned} \text{unc}_{B,t} &= \alpha_0 \\ &+ \alpha_1 \text{d\_cr}_{Arg,t-1} \text{dis}_{Arg,B} + ... + \alpha_6 \text{d\_cr}_{Tur,t-1} \text{dis}_{Tur,B} \\ &+ \alpha_7 \text{d\_cr}_{B,t-1} + \alpha_8 \text{macrocntrls}_{B,t} + \delta_B + \gamma_t + \varepsilon_{B,t} \end{aligned} \tag{10}$$

where all the abbreviations have the same meaning as in Equation (9). Additionally, the terms $\text{dis}_{Arg,B}$ and γ_t stand for the distance from initial-crisis country to the potentially-affected country B and for the time effects, respectively. To estimate Equation (10), I also run fixed-effects panel regressions, additionally controlling for time effects.

3.2.2 Methodology Used to Estimate the Effect of the Uncertainty on the Probability of a Crisis in Potentially-affected Countries

For the analysis of the effect of uncertainty on the probability of a crisis in a potentially-affected country, I specify the following estimation equation:

$$\begin{aligned} \text{Prob}(d\_cr_B = 1|x_{B,t}\beta_0) &= G(\beta_0 \\ &+ \beta_1 \sum_{A=Arg,...,Tur} (\text{ctg}_{A,B,t-1} * \text{d\_cr}_{A,t-1}) \\ &+ \beta_2 \text{unc}_{B,t-1} * \sum_{A=Arg,...,Tur} (\text{d\_cr}_{A,t-1}) + \delta_B + \gamma_t + \varepsilon_{B,t}) \end{aligned} \tag{11}$$

with $B = 1, 2, ..., 32; t = 1, 2, ..., 141$.

Since this study is interested in the increase of the probability of a crisis, I employ probit estimations. Hence, $G(.)$ is the standard normal cumulative distribution function. $\text{ctg}_{A,B,t-1}$ represents the alternative channels of contagion from country A to country B: common creditors, trade, dependence on a common overexposed fund investor, and finally also the market size of the crisis country. These are interacted with the crises in the initial-crisis countries taking into account that it is important to control for their effect in transmitting those crises to country B. I also include the interaction of uncertainty with the crises because it is the effect of uncertainty – if a crisis in country A takes place – which is of interest.

Probit models do not lend themselves to consistent estimates of the coefficients in a fixed effects regression. Hence, instead of a fixed-effects panel estimation, a pooled probit introducing dummies can capture the country effects and time effects. Additionally, I estimate a linear probability model to overcome the potential incidental-parameter problem that can arise in the described procedure. As a plausibility check, I repeat the regressions with the continuous return as dependent variable and run simple OLS regressions.

Using the interaction term of the uncertainty measure in B with the sum of crises variables in countries A as a regressor implies the following risk: It could be that the coefficient on this term simply picks up the direct effect of the crises in A on a crisis in B. To ensure that this is not the case, I estimate a set of regressions, in which I enter the uncertainty variable and the initial crises variables separately. In these very simple regressions, I use the following specification:

$$\begin{aligned}\text{Prob}(d\_cr_B = 1|x_{B,t}\beta_0) &= G(\beta_0 \\ &+ \beta_1 \text{d\_cr}_{A,t-1} + ... + \beta_6 \text{d\_cr}_{A,t-1} \\ &+ \beta_7 \text{unc}_{B,t-1} + \beta_8 \text{mgexp}_{B,t-1} + \delta_B + \varepsilon_{B,t})\end{aligned} \tag{12}$$

with $B = 1, 2, ..., 32; t = 1, 2, ..., 141$.

Again, the abbreviations stand for the same variables as before. Furthermore, I put the mean growth expectations explicitly in Equation (12) to emphasize that it is used in this simple regression as a summary of the situation of country B.

3.3 Results

The results of the empirical analysis suggest that the uncertainty channel of contagion does play a role in spreading crises across markets. First, I find a significant and robust effect of the initial crisis on the uncertainty in potentially-affected countries. Second, I find a significant and robust effect of the uncertainty in the second country on the probability of a crisis there.[35]

3.3.1 The Effect of a Crisis in an Initial-crisis Country on the Uncertainty in a Potentially-affected Country

The analysis of the effect of an initial crisis on disagreement about the fundamentals in potentially-affected countries shows an interesting pattern: I find that the Mexican, Russian, and Thai crises significantly increase disagreement about the fundamentals in other countries. The literature identifies these crises as surprise crises.

However, in the case of the three other crises in the sample – the Brazilian, Turkish, and Argentinean crises – the panel analysis shows a different pattern: The Turkish and Argentinean crises significantly decrease the uncertainty in potentially-affected countries. The effect of the Brazilian crisis is less clear. The literature identifies these crises as anticipated crises.

These results are robust to choosing regional sub-samples, emerging markets sub-samples, and including a large number of control variables. Table 5 summarizes the results of the fixed-effects panel regressions with those sub-samples.

[35]In the following, I show the results calculating the stock market returns from the MSCI index, using a return drop of more than 2 standard deviations below the sample mean as crisis criterion and employing a weighted average of current and following year GDP forecasts as basis for the uncertainty measure. However, I have run the estimations also with the return data from IFC, with two variations of the crisis criterion, and with the current year and the following year forecasts separately. The results of these different sets of analyses are qualitatively the same and quantitatively similar. Therefore, I do not include them in this paper.

(Table 5 here)

The different columns in Table 5 correspond to the regression results from different sub-samples. Column 1 shows the coefficients of the fixed-effects panel regression of uncertainty in all potentially-affected countries on the crises in all the initial crises countries and a set of control variables. Column 2 displays regression results of the regression of the crises in all initial crises countries on uncertainty in emerging market economies. Columns 3 to 10, then, show results for regressions of the regional crises in the sub-samples of all economies (columns 3, 5, 7, 9) and only the emerging economies (columns 4, 6, 8 and 10) within Asia (columns 3 to 6), within Eastern Europe (columns 7 and 8) and within Latin America (columns 9 and 10).

In all regressions, the lag of the 1994 Mexican, the 1998 Russian, and the 1997 Thai crises have a significant and positive effect on the uncertainty in the potentially-affected countries. Comparing columns 9 and 10 with columns 1 and 2 reveals that the effect of the Mexican crisis is stronger on uncertainty in Latin American countries (they are all emerging countries, which explains why columns 9 and 10 are identical) than on the entire sample of countries or the sub-sample of all emerging economies. A crisis event in Mexico leads to an increase of the standard deviation of growth expectations across country experts of 0.174 percentage points in Latin American countries. The Mexican crisis exerts a smaller effect on uncertainty in the sample of all emerging markets, increasing the standard deviation of growth expectations by 0.059 percentage points. This effect is slightly bigger than the one observed in the sample of all countries, where the increase is 0.044 percentage points.

The same pattern holds for the Russian and Thai crises. However, for these two crises, the difference in the magnitude of the effect within their own region, compared to the effect on the entire sample of countries, is not as large as for the Mexican crisis. The effect of the Thai crisis on uncertainty in emerging Asia is an increase of 0.123 percentage points of the standard deviation, while its effect on all Asian countries is a bit smaller: 0.112. In the sample of all emerging markets, the effect of the Thai crisis is 0.085 percentage points and in the sample of all the countries, the effect is 0.063. While the Russian crisis increases the standard deviation of growth expectations in Eastern European countries by 0.145 percentage points, its effect on all emerging and all countries amounts to 0.086 and 0.048 percentage points only.

These results suggest that the Mexican crisis has the strongest effect on uncertainty in other countries, in magnitude within its own region among the three mentioned crises. However, the Mexican crisis has less impact beyond its own region than have the Russian and the Thai crises. Furthermore, these results suggest that the Thai crisis has the biggest effect of all three crises in the developed world.

A closer look on results for the 2002 Argentinean, the 1999 Brazilian, and the 2001 Turkish crisis reveals a different picture. While the Argentinean crisis decreases the standard deviation of growth expectation by 0.146 percentage points in Latin American countries, the effect is weaker in the sample of all emerging markets and all countries: a decrease of 0.039 and 0.026, respectively. In case of the Brazilian crisis, only the decrease of 0.027 percentage points of standard deviation of the growth expectation in the sample of all countries is significant at the five-percent level, while the effect of this crisis is insignificant in all the sub-samples. The Turkish crisis delivers the same pattern as the Argentinean crisis. However, the Turkish crisis presents one interesting additional finding. First, estimating the effect of the Turkish crisis in the sub-sample of Eastern European countries shows that the Turkey crisis yields a decrease of uncertainty of 0.043 measured in the standard deviation of growth expectations in those countries. Second, estimating the effect of the Turkish crisis in the subsamples of emerging Asian countries and all Asian countries, the effect is much stronger: There the crisis in Turkey results in a decrease of 0.1 and 0.074 percentage points respectively.

These results suggest that the negative effects of the Argentinean and Turkish crises on uncertainty in potentially-affected countries are stronger within their own regions than beyond. The Turkish crisis shows a bigger effect in Asia than in Eastern Europe. The effect of the Brazilian crisis is less clear.

The coefficients on the control variables used in the regressions have the expected signs. In particular, as expected, the lag of the mean of the growth expectations impacts uncertainty negatively. This variable can be seen as a summary of the state of the fundamentals and the expectations about it. If the fundamentals are good – or everyone expects them to be good – then disagreement about the fundamentals decreases. The lag of the crises in the potentially-affected countries shows a positive and significant effect on uncertainty. Past stock market volatility also has a strong positive and significant effect on uncertainty.[36] Additionally, I use the ICRG financial, economic, and political risk indices as summary of the fundamentals following Broner et al. (2006). The coefficients on these variables are mostly not significant in the regressions.

To further ensure the robustness of the effects that the above regressions reveal, I run a second set of regressions, controlling for time effects. As explained in section 3.2.1, controlling for time effects in the above setting is not possible. To circumvent this problem, I interact the crisis variable with the distance between the crisis variable and the potentially-affected countries.[37] This creates heterogeneity in the crisis variable across countries, making control of time effects possible. Clearly, the meaning of the explanatory variable is slightly changed. Now additionally, whether the distance in the sense of Rose (2004) increases or decreases the effect of a crisis on the uncertainty in the potentially-affected countries, makes a difference.

I repeat the above fixed-effects panel regression, replacing the lagged crises variables for the Argentinean, Brazilian, Mexican, Russian, Thai, and Turkish crisis with the interaction

[36] By introducing the stock market volatility, I lose India from the sample and also lose a non-negligible amount of observations. Therefore, I have run all the regressions also without the stock market variable. The results are qualitatively and quantitatively very similar. For this reason only the results including the stock market variable are displayed. In regressions without the stock market volatility, the coefficient on past crisis in country B is slightly higher.

[37] By using the distance variable, I lose Slovakia and Taiwan, for which the distances to the initial crises countries are not available in the data set underlying Rose (2004).

term between those crises variables with the distance to the potentially-affected countries and control for time effects in addition. Table 6 in Appendix 6 displays the results. The overall pattern of effects remains the same as in the first set of regressions. The effects are still highly significant. The only exception is the coefficient on the interaction term of the Russian crisis with the distance variable in the regressions with the samples of all and of all emerging markets, which become insignificant.

As the effect of the crises in the initial countries on uncertainty becomes smaller, the question arises whether this stems from the interaction of the crises with the distance or from the control for time effects. To disentangle these two cases, I also run regressions with the interaction variables without controlling for time effects. The results are displayed in Table 7 in Appendix 6. The regression results are very similar to the ones where I control for time effects. This result suggests that the interaction with the distance variable explains the lower coefficients and thus the weaker effect of the crisis in the initial-crisis countries on uncertainty; the control for time effects is not driving this result. Hence, it is safe to say that the effect of the initial-crisis country diminishes with an increasing distance. Taken together, these regression outcomes confirm the observations from the first set of regressions. The results are robust against the inclusion of time effects.

To summarize the findings of the first step of the analysis: The analysis shows that the Mexican, the Russian, and the Thai crises significantly increase uncertainty in potentially-affected countries. The effect is stronger within the region where the crisis takes place. The Argentinean, the Turkish, and, to a lesser extent, the Brazilian crises decrease uncertainty in potentially-affected countries. These last three crises have a stronger negative effect within their region. The effect appears to decrease with increasing distance.

These findings are in line with the hypotheses derived from the theoretical model. Recall that surprise crises increase uncertainty in other countries, while anticipated crises decrease uncertainty in other countries. The findings regarding the different regional effects are not captured by the theoretical model.

3.3.2 The Effect of the Uncertainty on the Probability of a Crisis in a Potentially-affected Country

In the second step of the analysis, I show robustly that uncertainty in the potentially-affected country increases the probability of a crisis there. These results are summarized in Tables 8 to 12.

Firstly, I run a pooled probit regression of the crises in the potentially-affected countries on the interaction of uncertainty in country B, with the sum of all initial crises countries, controlling for a set of variables including country and time effects. Apart from the controls for country and time effects, these variables classify in two categories: 1) domestic control variables and 2) alternative contagion channels, which could influence the likelihood of a crisis in the potentially-affected countries. Table 8 displays the results. The results of the pooled probit estimations including country and time controls are displayed in column 1 for the sample of all countries and column 2 for the sample of all emerging market countries. The estimation results of the linear probability model are shown in columns 3 and 4. The outcomes of the simple OLS regressions with the continuous return variable as dependent variable appear in columns 5 and 6.

Columns 1 and 2 of Table 8 show the lag of uncertainty interacted with the sum of crises in all initial crises countries has a positive and strongly significant effect on the probability of a crisis in the potentially-affected country. The effect is stronger in emerging economies. Introducing the dummies into the pooled probit regression does not seem to create a severe incidental parameter problem. The magnitude of the effect is, indeed, smaller in columns 3 and 4 but the effect is still strongly significant and not negligible. The effect of the uncertainty on the continuous return variable in columns 5 and 6 not being significant is not problematic. The theoretical model is about crises, which are extreme events. The regression with the continuous return variable as regressand is a plausibility check, only. For example, if an increase in uncertainty increased the return, while simultaneously increasing the probability of a crisis, this would worry.

Secondly, I run the regressions with the interaction of uncertainty with the sum of the crises in Mexico, Russia and Thailand. These are the crises identified to increase the uncertainty in other countries. The results of these regressions are summarized in Table 9.

(Table 9 here)

Clearly, the effects of uncertainty are stronger in the current regression than in those with all initial crises countries.[38] Here, also the coefficients of the uncertainty term are significant when using the continuous return variable as regressand.

Calculating marginal effects makes clear that the effect of the uncertainty on the probability of crises in the potentially-affected countries is not negligible. Details are shown in Table 12.

(Table 12 here)

The control variables have the expected signs. With regard to country characteristics the following variables are controlled for: the lag of the mean growth expectations, the lag of stock market volatility, and the ICRG risk indices for economic, financial, and political risk.

[38] This finding goes beyond what is explained by the theoretical model, which would not distinguish the intensity of an increase or decrease of uncertainty after a surprise crisis or an anticipated crisis.

With regard to alternative contagion channels, the following variables are controlled for: the common creditor channel of contagion, the direct trade channel, contagion from important stock markets, and contagion through common overexposed fund investors. I use slightly different definitions than the literature to construct the index of common creditors and the index of trade share with the initial-crisis country. The definitions that I use are more plausible in the context of stock market drops, rather than the existing indices which have been developed to study contagion of currency crises. Section 3.1 explains the construction of these variables exactly. I estimate regressions, which include the channel through overexposed fund investors separately, and show the results in Table 10. This is due to the fact that I have the index of overexposed common creditors only for the sample of emerging markets without Ukraine.[39]

The market size of the initial-crisis country turns out to be not significant in the regressions (see Tables 8 to 10). If not controlling for overexposed common fund investors, I find that common creditors and trade share have a high explanatory power for the occurrence of a crises in the potentially-affected countries (see Tables 8 and 9). However, if I introduce the control of the overexposed common fund investor index, these two variables become insignificant, which makes them appear not entirely robust, at least in the emerging market sample, for which I can test the overexposure channel. Notably, the overexposure channel cannot significantly contribute to the explanation of the continuous fund returns in columns 5 and 6 in Table 10, while Broner et al. (2006) find a significant effect. This difference could stem from the severe test with control for country and time effects that I run in the present analysis.

As explained in section 3.2.2, care must be taken to ensure against only picking up the direct effect of the crises in the initial-crises countries when interacting the uncertainty in B with the sum of crises in the initial-crises countries. The results in Table 11 show that the uncertainty has a distinct positive and strongly significant effect on a crisis event in the same economy.

The possibility of reverse causality is not tackled in this second step of my empirical analysis. This problem could arise if the crisis in B itself caused the uncertainty to increase. There are two answers to this concern: First, the present analysis is interested in the uncertainty that is caused by crises elsewhere. I show robustly that a crisis in A significantly influences uncertainty in country B. In this step, reverse causality is unlikely. Hence, this part of the analysis is not affected by the endogeneity concern.

The problem arises only in the second step. Here, singling out perfectly the uncertainty caused by the crisis in country A is not possible. However, interacting uncertainty in B with the crises in the initial crises countries and, at the same time, controlling for domestic causes of increased uncertainty provides the second answer to the endogeneity concern. The interaction allows to consider exclusively the relevant time periods. Therefore, uncertainty

[39] I am very thankful to Broner et al. (2006) for making their overexposure index available to me. Due to the expensive underlying source data, I would not have been able to control for this relevant contagion channel otherwise.

caused by the crises in the other countries should be especially high. Additionally, controlling for the fundamentals in country B in the same regressions corrects for domestic causes of increased uncertainty in B. As a check in the second step, I estimate a set of regressions, in which I include uncertainty and crisis indices for the initial crises countries both as separate explanatory variables. Also in these regressions, the effect of uncertainty is positive and strongly significant. In a follow-up check, I run a further set of regressions, including exclusively either the crises indices in countries A or the uncertainty in B as explanatory variables. The coefficient of uncertainty does not change significantly. Thereby, I make sure that the uncertainty has a separate effect on the probability of crises in B from the direct effect of the crisis in A.

Instrumental variable estimation is not an answer to the endogeneity concern in the present set up. Instrumenting uncertainty, for example, by its past realizations does not help. In the case where the instrument reaches far enough back into the past, the instrument might be realized before the crises in the initial-crisis country. It would then pick up exactly the part of uncertainty that is not of interest in this analysis. Therefore, the series of checks conducted in the present study appear to be the best available option.

These arguments support plausibility and reliability of the results. Further soundness comes when taking these arguments together with the results of the analysis on sudden stops in Koehler (2006). There is shown the strongly significant effect of uncertainty on the occurrence of a crisis after taking care of the endogeneity problem.

Together with the findings in section 3.3.1, the sets of regressions in the current section support the theoretical model. Uncertainty in potentially-affected countries increases with the occurrence of a surprise crisis in initial-crises countries. In turn, this increase in uncertainty leads to an increase of the probability of a crisis in potentially-affected countries. In case of an anticipated crisis in the first country, the uncertainty in the second country is reduced. In turn, this decreased uncertainty decreases the probability of a crisis in the second country. The fact that the coefficients on the interaction term in Table 8 are larger than those in Table 9 suggests that the decreasing effect of a decreasing uncertainty on the crisis probability after an anticipated initial crisis is weaker than the increasing effect of an increased uncertainty after a surprise crisis in the initial-crisis country on the crisis probability. However, the weaker results in Table 8 could also stem from the Brazilian crisis not having a clear-cut effect on the uncertainty in potentially-affected countries.

These empirical results align with the theoretical model. First of all, a large part of the literature agrees that there was much less international response in form of crisis in other countries to the Brazilian, the Turkish, and the Argentinean crisis than to the three other crises.[40] Additionally, Didier et al. (2006) and Mondria (2006) argue that the Brazilian, Turkish, and Argentinean crises were anticipated by the investors while the Mexican, Thai, and Russian crises caught them by surprise.

[40]See, for example, Kaminsky et al. (2000) or Didier et al. (2006).

4 Policy Implications

The first, obvious implication of my analysis is that investors and governments should closely monitor fundamentals also of other countries, especially in the region and in adjacent countries. Surprise crises appear to be especially bad because they set off mechanisms that worsen the situation further. This paper illustrates such a mechanism through the uncertainty about the fundamentals.

Second, once a surprise crisis has hit a first country, governments need to apply policies that counteract the increase in uncertainty about the fundamentals in country B. One venue could be to develop mechanisms for such situations through which governments could disseminate credibly very precise information about the state of their economy. In this model, I have not been concerned with credibility issues, so I can only infer something about a credible government. In reality, governments might not be credible – they might be tempted strongly to signal that the fundamentals in their country are very satisfying. However, one way toward overcoming the credibility problem and helping private investors receive more precise private signals, would be to allow full access to the government accounts to a few independent institutions, which could then sell the information to private investors. Such a procedure ensures that private investors have private information but with little dispersion around the true value of the fundamentals. Another venue would be to think about subsidies for information-gathering technology.

5 Conclusion

In this paper, I illustrate the uncertainty channel of contagion in a coordination game and then validate the predictions empirically. In particular, I find that surprise crises in an initial-crisis country such as the Mexican, Thai, or Russian crises increase the probability of a crisis in other countries. In the case of an anticipated crisis such as the Brazilian, Turkey, or Argentinean crises, uncertainty is reduced making crises in potentially-affected countries less likely. Additionally, the empirical analysis shows that the effects through uncertainty are stronger in potentially-affected countries within the same region as and closer to the initial-crisis country.

The results of the present analysis suggest that investors and governments should closely monitor the fundamentals of neighboring countries to minimize the risk of a surprise crisis. Second, policy makers should take uncertainty about the fundamentals into account. Once a surprise crisis happens elsewhere, policy makers should be ready to counteract the increase in the disagreement about the fundamentals by adequate policies. Strategies that help private investors receive precise private signals appear prudent in the light of this analysis.

The present analysis also confirms the findings of the relevance of other contagion channels especially through overexposed fund investors, also through trade links and common creditors. However, on top of these channels, which have been analyzed by the literature for some time, uncertainty does play a role in explaining contagion patterns. And, as the analysis of marginal effects shows, the effect is not negligible.

In this paper, I have taken the change in dispersion of the private signals in the second economy as given if a crisis happens in the first country. A worthwhile future research agenda is to explicitly model the optimal choice of spending on information-gathering technology. This would result in an endogenous change in dispersion of the private signals in the second market.

As to the empirical analysis, future research moving to higher frequency data, if available, could be worthwhile. This step might allow the exploration of more convincing ways of determining the direction of causality.

6 Appendix

6.1 Lemma Proofs

6.1.1 Proof of Lemma 1 (Monotonicity of P)

Proof. The monotonicity of P in θ^i can be very easily shown: In

$$P(\theta^i, I_T) = R \cdot prob(\theta^i \leq T) - E(\frac{1}{2}\theta^2|\theta^i)$$

R does not depend on θ^i. In addition,

$$\frac{\partial prob(\theta^i \leq T)}{\partial \theta^i} = \begin{cases} 0 & \text{if } T < \theta^i - 2\eta \text{ and } T > \theta^i + 2\eta \\ < 0 & \text{if } \theta^i - 2\eta < T < \theta^i + 2\eta \end{cases}$$

Therefore, the term $R \cdot prob(\theta^i \leq T)$ is weakly decreasing in θ^i. The term

$$-\frac{\partial E(\frac{1}{2}\theta^2|\theta^i)}{\partial \theta^i} < 0$$

is strictly decreasing in θ^i. As a consequence, $P(\theta^i, I_T)$ is strictly monotonically decreasing in θ^i. ■

6.1.2 Proof of Lemma 2 (Uniqueness of Equilibrium)

Proof. Equation (6) can be rewritten as follows:

$$P(\theta^\star, I_{\theta^\star}) = R \cdot prob(\theta^j \leq \theta^\star) - \frac{1}{2\eta}\int_{\theta^\star-\eta}^{\theta^\star+\eta} \frac{1}{2}\theta^2 d\theta = 0 \tag{13}$$

This leads to

$$P(\theta^\star, I_{\theta^\star}) = \frac{1}{2}R - \frac{1}{2\eta}[\frac{1}{6}\theta^3]_{\theta^\star-\eta}^{\theta^\star+\eta} = 0 \tag{14}$$

This equation defines $\theta^\star$ and can easily be rearranged to equation (7). ■

6.2 Iterated Elimination of Dominated Strategies

The elimination is started at the borders of the dominance ranges. Due to the strict monotonicity in θ^i, there exist unambiguous signals $\overline{\theta}^1 < \overline{\theta}^0 = \overline{\theta}$ and $\underline{\theta}^1 > \underline{\theta}^0 = \underline{\theta}$, such that

$$P(\theta^i, I_{\overline{\theta}^0}) < 0 \quad \text{for all} \quad \theta^i > \overline{\theta}^1 \quad \text{and} \quad P(\theta^i, I_{\underline{\theta}^0}) > 0 \quad \text{for all} \quad \theta^i < \underline{\theta}^1$$

As $\overline{\theta}^0 > \underline{\theta}^0$, it also holds that $\overline{\theta}^1 > \underline{\theta}^1$. For the case of the upper border of the multiplicity area, this means: Given that the other agents do not invest when receiving signals above $\overline{\theta}^0$, the investment does not pay for signals above $\overline{\theta}^1$ either. Where I find $\overline{\theta}^1$ by calculating $P(\theta^i = \overline{\theta}^1, I_{\overline{\theta}^0})$. This process can be iterated. Given that the other agents do not invest when receiving signals above $\overline{\theta}^n$, it does not pay to invest at a signal $\overline{\theta}^{n+1}$ with $\overline{\theta}^{n+1} < \overline{\theta}^n$. The signals $\overline{\theta}^{n+1}$ are found by setting the expected payoff difference to 0, reflecting indifference between investment and no investment for investor i:

$$P(\overline{\theta}^{n+1}, I_{\overline{\theta}^n}) = R \cdot prob(\theta^j \leq \overline{\theta}^n) - E(\frac{1}{2}\theta^2|\theta^i = \overline{\theta}^{n+1}) \tag{15}$$

The sequence $\overline{\theta}^n$ is decreasing, monotone and bounded. By the common knowledge of rationality, this process is driven to its limit of $\overline{\theta}^\star = lim_{n\to\infty}\overline{\theta}^n$. Concretely, it is possible to find a value $\overline{\theta}^\star$ such that

$$P(\overline{\theta}^\star, I_{\overline{\theta}^\star}) = 0 \tag{16}$$

$\overline{\theta}^\star$ has the interpretation that above this signal all agents do not invest with certainty.

At the lower bound of the multiplicity area, the analogue situation occurs, just with the sequence $\underline{\theta}^n$ being increasing. There one iterates until one finds:

$$P(\underline{\theta}^\star, I_{\underline{\theta}^\star}) = 0 \tag{17}$$

That means, one iterates until one finds a maximum (minimum) signal at which agent i is indifferent between investing and not, and which is at the same time the threshold of the switching strategy of all other agents, when starting off at $\overline{\theta}^0 = \overline{\theta}$ ($\underline{\theta}^0 = \underline{\theta}$).

The switching strategies $I_{\underline{\theta}^\star}$ and $I_{\overline{\theta}^\star}$ are Nash equilibria of the private information game. According to Milgrom and Roberts (1990), in all games with strategic complementarity, the highest and the lowest equilibrium that resist the iterative elimination of dominated strategies are Nash equilibria. Put the other way round: These Nash equilibria can never be eliminated. If $\overline{\theta}^\star = \underline{\theta}^\star$, there exists an unambiguous signal $\theta^\star$, below which in equilibrium all agents will invest and above which no one invests.

6.3 Figures and Tables

Developed Countries				Emerging Market Countries			
Asia & Australia	Eastern Europe	Latin America	Western Europe & North America	Asia & Australia	Eastern Europe	Latin America	Western Europe & North America
Australia			Canada	China	Czech Republi	Argentina	
Japan			France	Hong Kong	Hungary	Brazil	
New Zealand			Germany	India	Poland	Chile	
			Italy	Indonesia	Romania	Columbia	
			Netherlands	Korea	Russia	Mexico	
			Norway	Malaysia	Slovakia	Peru	
			Spain	Singapore	Turkey	Venezuela	
			Sweden	Taiwan	Ukraine		
			Switzerland	Thailand			
			UK				
			USA				

The sample comprises 38 countries, of which 15 developed and 23 Emerging Market countries.
There are 7 Latin American, 12 Asian & Australian, 8 Eastern European and 11 Western European and North American countries.

Table 1: Country sample

Variables	Measures	Sources
Crisis measure:		
Drops in stock market returns	Basis for the crisis measure is the percentage change in US $ national, total return stock market indices relative to the previous month. A month is counted as a crisis month if the total return drops at least 2 standard deviations below the sample mean. Subsequent months are also counted as crisis months until the return moves back into the one standard deviation band around the sample mean.	2 sets of crisis measures: 1) IFC investable, total return indices, 2) MSCI total return indices. In both cases I have to use local sources for Romania, Slovakia and Romania. To convert these three national indices from national currency to US $ I use exchange rate end of period data from the IMF: IFS.
Explanatory Variable:		
Uncertainty measure	Monthly data of the weighted average of the standard deviations of the current and following year forecast of economic growth. The standard deviation is calculated for the expectations that experts for the specific economy utter at a particular point in time. In January the standard deviation of the current year forecasts is weighted with 11/12 and the standard deviation of the follwoing year forecasts with 1/12. In February the current year value receives 10/12 weight and the follwing year one 2/12. This scheme continues until December with a weighting of 0/12 for the current year value and 12/12 for the following year value.	Consensus Economics

Table 2: List of variables

Variables	Measures	Sources
Domestic control variables		
Mean growth expectations	Monthly data of the weighted average of the mean of the current and following year forecast of GDP growth. The mean is calculated for the expectations that experts for the specific economy utter at a particular point in time. The weighting scheme is the same as for the standard deviation.	Consensus Economics
Stock market volatility	Standard deviation of daily returns calculated for a time window of three months from month t-2 to t.	Cf. crisis measure. However restricted availability of daily returns.
Changes in the political risk	Difference in political risk indicatior relative to previous month.	ICRG
Changes in the economic risk	Difference in economic risk indicatior relative to previous month.	ICRG
Changes in the financial risk	Difference in financial risk indicatior relative to previous month.	ICRG
Distance to initial crisis country	Calculated by Rose (2004)	Rose (2004)
Domestic liability dollarization	Developed countries: Local asset positions in foreign currency by BIS reporting banks as a share of GDP. EMs: Dollar deposits plus bank foreign borrowing as a share of GDP.	Calvo, Izquierdo, Mejia (2004): BIS, Honohan and Shi (2002), Central Banks of Australia, New Zealand, Columbia, Korea, Brazil, IMF: IFS
TOT growth	Developed countries: Local asset positions in foreign currency by BIS reporting banks as a share of GDP. EMs: Dollar deposits plus bank foreign borrowing as a share of GDP.	Calvo, Izquierdo, Mejia (2004): BIS, Honohan and Shi (2002), Central Banks of Australia, New Zealand, Columbia, Korea, Brazil, IMF: IFS
Credit growth	Credit to private setor, monthly rate of change	IMF: IFS

Table 3: List of variables (continued)

Alternative contagion channels		
Index of common creditors	Degree of dependence on the same creditors as the initial crisis country. I calculate the index as the sum over all creditors of the product of the dependence of country B on creditor i times the importance of the initial crisis country, A, for creditor i. The dependence of country B on creditor i is the ratio of the volume that country B borrows from creditor i relative to the total borrowing by country B. The importance of country A to creditor i is the ratio of the volume that creditor i lends to country A relative to total lending by creditor i.	BIS quaterly review, consolidated banking data, table 9B. I construct the monthly timeseries from the quarterly observations by interpolation.
Trade share	Exports from country B to the initial crisis country relative to total exports by country B	IMF: Direction of trade statistics
Stock market size	Market value of IFC investable / FTSE index	IFC investable/ FTSE index
Index of common overexposed fund investors	Degree of dependence on fund investors that are overexposed to the initial crisis country	Broner, Gelos, Reinhart (2006)

Table 4: List of variables (continued)

Panel regressions of uncertainty in B with fixed effects on the lag of crisis in initial crises countries

Step 1 Effect of crises in the initial crises countries on the uncertainty in other countries

Dependent Variable uncertainty in country B at t. The initial crises countries are excluded as affected countries.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	all crises, all countries	all crises, emerging markets	regional crises, asia	regional crises, emerging asia	regional crises, asia + turkey	regional crises, emerging asia + turkey	regional crises, eastern europe	regional crises, emerging eastern europe	regional crises, latin america	regional crises, emerging latin america
lag of crisis in Arg	-0.026**	-0.039**							-0.146***	-0.146***
	(0.011)	(0.019)							(0.041)	(0.041)
lag of crisis in Bra	-0.027**	-0.021							-0.041	-0.041
	(0.013)	(0.024)							(0.051)	(0.051)
lag of crisis in Mex	0.044**	0.059*							0.174***	0.174***
	(0.017)	(0.032)							(0.061)	(0.061)
lag of crisis in Rus	0.048***	0.086***					0.145***	0.145***		
	(0.011)	(0.019)					(0.031)	(0.031)		
lag of crisis in Tha	0.063***	0.085***	0.112***	0.123***	0.108***	0.116***				
	(0.009)	(0.016)	(0.019)	(0.026)	(0.019)	(0.026)				
lag of crisis in Tur	-0.036***	-0.070***			-0.074***	-0.100***	-0.043*	-0.043*		
	(0.009)	(0.017)			(0.019)	(0.026)	(0.025)	(0.025)		
lag of crisis in B	0.164***	0.137***	0.227***	0.221***	0.230***	0.229***	0.064*	0.064*	0.136**	0.136**
	(0.018)	(0.025)	(0.030)	(0.036)	(0.030)	(0.036)	(0.036)	(0.036)	(0.055)	(0.055)
lag of mean growth expectations	-0.119***	-0.122***	-0.122***	-0.122***	-0.125***	-0.126***	-0.103***	-0.103***	-0.106***	-0.106***
	(0.002)	(0.003)	(0.004)	(0.005)	(0.004)	(0.005)	(0.008)	(0.008)	(0.009)	(0.009)
lag of stock market volatility	5.092***	5.468***	5.332***	5.764***	4.968***	5.190***	3.896***	3.896***	6.490***	6.490***
	(0.357)	(0.493)	(0.734)	(0.870)	(0.734)	(0.873)	(0.723)	(0.723)	(1.355)	(1.355)
lag of economic risk index	-0.000	0.002	-0.004	-0.006	-0.003	-0.006	-0.002	-0.002	0.022*	0.022*
	(0.004)	(0.006)	(0.006)	(0.008)	(0.006)	(0.008)	(0.013)	(0.013)	(0.011)	(0.011)
lag of financial risk index	-0.007*	-0.014**	-0.009	-0.007	-0.009	-0.008	-0.005	-0.005	-0.021	-0.021
	(0.003)	(0.006)	(0.007)	(0.009)	(0.007)	(0.009)	(0.010)	(0.010)	(0.013)	(0.013)
lag of political risk index	-0.003	-0.001	-0.011*	-0.022**	-0.010	-0.021**	-0.003	-0.003	0.012	0.012
	(0.003)	(0.005)	(0.006)	(0.009)	(0.006)	(0.009)	(0.010)	(0.010)	(0.008)	(0.008)
Constant	0.842***	1.100***	1.095***	1.232***	1.131***	1.289***	0.850***	0.850***	1.029***	1.029***
	(0.012)	(0.022)	(0.030)	(0.044)	(0.031)	(0.046)	(0.027)	(0.027)	(0.046)	(0.046)
Observations	2657	1293	944	598	944	598	353	353	342	342
Number of country	30	16	9	6	9	6	6	6	4	4
R-squared	0.60	0.65	0.70	0.74	0.70	0.74	0.46	0.46	0.45	0.45

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Step 1: Effect of crisis in A on uncertainty in B

Panel regressions of uncertainty in B with fixed effects on the lag of crisis in initial crises countries

Step 1 Effect of crises in the initial crises countries on the uncertainty in other countries

Dependent Variable uncertainty in country B at t. The initial crises countries are excluded as affected countries.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	all crises, all countries	all crises, emerging markets	regional crises, asia	regional crises, emerging asia	regional crises, asia + turkey	regional crises, emerging asia + turkey	regional crises, eastern europe	regional crises, emerging eastern europe	regional crises, latin america	regional crises, emerging latin america
lag of interaction crisis in Arg* distance to B	-0.004***	-0.006***							-0.016***	-0.016***
	(0.001)	(0.002)							(0.005)	(0.005)
lag of interaction crisis in Bra* distance to B	-0.002	-0.001							-0.007	-0.007
	(0.001)	(0.003)							(0.006)	(0.006)
lag of interaction crisis in Mex* distance to B	0.009***	0.010**							0.028***	0.028***
	(0.002)	(0.004)							(0.007)	(0.007)
lag of interaction crisis in Rus* distance to B	0.000	0.000					0.009**	0.009**		
	(0.000)	(0.001)					(0.004)	(0.004)		
lag of interaction crisis in Tha* distance to B	0.005***	0.009***	0.010***	0.009**	0.010***	0.010**				
	(0.001)	(0.002)	(0.003)	(0.004)	(0.003)	(0.004)				
lag of interaction crisis in Tur* distance to B	-0.002*	-0.003			-0.005*	-0.005	0.003	0.003		
	(0.001)	(0.002)			(0.003)	(0.004)	(0.003)	(0.003)		
lag of crisis in B	0.165***	0.153***	0.238***	0.212***	0.242***	0.218***	0.067***	0.067***	0.108**	0.108**
	(0.017)	(0.025)	(0.032)	(0.039)	(0.032)	(0.039)	(0.025)	(0.025)	(0.049)	(0.049)
lag of mean growth expectations	-0.121***	-0.132***	-0.132***	-0.132***	-0.133***	-0.133***	-0.100***	-0.100***	-0.121***	-0.121***
	(0.003)	(0.004)	(0.005)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)
lag of stock market volatility	4.904***	4.231***	3.799***	3.896***	3.732***	3.791***	0.720	0.720	3.900***	3.900***
	(0.425)	(0.656)	(0.786)	(0.974)	(0.785)	(0.976)	(1.051)	(1.051)	(1.227)	(1.227)
lag of economic risk index	-0.003	-0.000	-0.005	-0.005	-0.004	-0.004	-0.018*	-0.018*	0.016	0.016
	(0.004)	(0.006)	(0.006)	(0.008)	(0.006)	(0.008)	(0.010)	(0.010)	(0.010)	(0.010)
lag of financial risk index	-0.006*	-0.013**	-0.012*	-0.012	-0.012*	-0.012	0.008	0.008	-0.017	-0.017
	(0.003)	(0.006)	(0.007)	(0.009)	(0.007)	(0.009)	(0.007)	(0.007)	(0.012)	(0.012)
lag of political risk index	-0.004	-0.003	-0.012*	-0.021**	-0.011*	-0.020**	-0.006	-0.006	0.008	0.008
	(0.003)	(0.005)	(0.007)	(0.009)	(0.007)	(0.009)	(0.008)	(0.008)	(0.007)	(0.007)
time effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant	1.649***	2.312***	2.111***	-0.312	2.116***	-0.230	0.588	0.588	2.510***	2.510***
	(0.108)	(0.276)	(0.235)	(0.754)	(0.235)	(0.756)	(5.086)	(5.086)	(0.352)	(0.352)
Observations	2440	1076	844	498	844	498	236	236	342	342
Number of country	27	13	8	5	8	5	4	4	4	4
R-squared	0.64	0.70	0.73	0.77	0.73	0.77	0.68	0.68	0.58	0.58

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Step 1: Effect of crisis in A on uncertainty in B, interacted explanatory variable, time effects

Panel regressions of uncertainty in B with fixed effects on the lag of crisis in initial crises countries

Step 1 Effect of crises in the initial crises countries on the uncertainty in other countries

Dependent Variable uncertainty in country B at t. The initial crises countries are excluded as affected countries.

Data source: MSCI

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	all crises, all countries	all crises, emerging markets	regional crises, asia	regional crises, emerging asia	regional crises, asia + turkey	regional crises, emerging asia + turkey	regional crises, eastern europe	regional crises, emerging eastern europe	regional crises, latin america	regional crises, emerging latin america
lag of interaction crisis in Arg* distance to B	-0.005***	-0.008***							-0.023***	-0.023***
	(0.001)	(0.002)							(0.006)	(0.006)
lag of interaction crisis in Bra* distance to B	-0.005***	-0.007**							-0.013*	-0.013*
	(0.001)	(0.003)							(0.007)	(0.007)
lag of interaction crisis in Mex* distance to B	0.012***	0.019***							0.041***	0.041***
	(0.002)	(0.004)							(0.007)	(0.007)
lag of interaction crisis in Rus* distance to B	0.001	0.000					0.010***	0.010***		
	(0.000)	(0.001)					(0.003)	(0.003)		
lag of interaction crisis in Tha* distance to B	0.005***	0.008***	0.011***	0.014***	0.010***	0.013***				
	(0.001)	(0.002)	(0.003)	(0.004)	(0.003)	(0.004)				
lag of interaction crisis in Tur* distance to B	-0.005***	-0.009***			-0.011***	-0.015***	-0.003	-0.003		
	(0.001)	(0.002)			(0.002)	(0.003)	(0.003)	(0.003)		
lag of crisis in B	0.174***	0.165***	0.262***	0.259***	0.262***	0.263***	0.077***	0.077***	0.111**	0.111**
	(0.018)	(0.025)	(0.033)	(0.040)	(0.032)	(0.040)	(0.026)	(0.026)	(0.053)	(0.053)
lag of mean growth expectations	-0.120***	-0.125***	-0.121***	-0.121***	-0.126***	-0.127***	-0.101***	-0.101***	-0.108***	-0.108***
	(0.003)	(0.004)	(0.004)	(0.006)	(0.004)	(0.006)	(0.006)	(0.006)	(0.009)	(0.009)
lag of stock market volatility	4.983***	5.210***	5.436***	5.797***	4.830***	4.831***	1.969*	1.969*	6.633***	6.633***
	(0.431)	(0.661)	(0.787)	(0.961)	(0.785)	(0.968)	(1.098)	(1.098)	(1.306)	(1.306)
lag of economic risk index	-0.003	-0.000	-0.005	-0.007	-0.004	-0.004	-0.015	-0.015	0.016	0.016
	(0.004)	(0.006)	(0.007)	(0.009)	(0.007)	(0.008)	(0.010)	(0.010)	(0.011)	(0.011)
lag of financial risk index	-0.006*	-0.013**	-0.011	-0.010	-0.011	-0.010	0.007	0.007	-0.020	-0.020
	(0.003)	(0.006)	(0.007)	(0.009)	(0.007)	(0.009)	(0.007)	(0.007)	(0.013)	(0.013)
lag of political risk index	-0.003	-0.001	-0.013*	-0.025**	-0.011	-0.022**	-0.010	-0.010	0.012	0.012
	(0.003)	(0.006)	(0.007)	(0.010)	(0.007)	(0.010)	(0.008)	(0.008)	(0.008)	(0.008)
time effects	no	no	no	no	no	no	no	no	no	no
Constant	0.848***	1.164***	1.105***	1.276***	1.157***	1.361***	0.839***	0.839***	1.032***	1.032***
	(0.014)	(0.029)	(0.031)	(0.049)	(0.032)	(0.052)	(0.031)	(0.031)	(0.045)	(0.045)
Observations	2440	1076	844	498	844	498	236	236	342	342
Number of country	27	13	8	5	8	5	4	4	4	4
R-squared	0.62	0.68	0.70	0.75	0.71	0.76	0.62	0.62	0.48	0.48

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

Table 7: Step 1: Effect of crisis in A on uncertainty in B, interacted explanatory variable, no control for time effects

Panel regressions of crisis in potentially affected country on the lagged uncertainty in B

Step 2 Effect of uncertainty in a country on the probability of a crisis there if a crisis takes place in an initial crisis country

Dependent Variable crisis as measured by significant negative returns in country B at t

The considered crises periods are Mexico 1994/5, Thailand 1997, Russia 1998, Brazil 1999, Turkey 2001, Argentina 2002

	(1)	(2)	(3)	(4)	(5)	(6)
					returns as dep. Variable	
	pooled probit all crises, all countries	pooled probit all crises, emerging markets	linear probability all crises, all countries	linear probability all crises, emerging markets	OLS, all crises, all countries	OLS, all crises, emerging markets
lag of interact. uncert. in B & crisis in all initial crisis cntrs.	0.100**	0.125**	0.040***	0.025***	0.001	0.003
	(0.047)	(0.050)	(0.006)	(0.009)	(0.002)	(0.004)
lag of interact. com creditors & crisis in A	5.825**	4.963	0.165**	1.677**	-0.017	-0.316
	(2.930)	(3.475)	(0.076)	(0.653)	(0.032)	(0.267)
lag of interact. tradeshare & crisis in A	6.918***	7.190***	1.441***	1.331***	-0.465***	-0.475***
	(2.551)	(2.630)	(0.264)	(0.405)	(0.113)	(0.166)
lag of interact. market size & crisis in A	-0.000	-0.000	-0.000*	-0.000	0.000***	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
lag of mean growth expectation	0.127***	0.120***	0.011**	0.010	-0.009***	-0.009***
	(0.041)	(0.044)	(0.004)	(0.007)	(0.002)	(0.003)
lag of stockmarket volatiltiy	9.828**	7.310	1.824***	0.981	-0.369*	-0.313
	(4.350)	(4.607)	(0.488)	(0.687)	(0.208)	(0.281)
lag of economic risk index	-0.064	-0.076	-0.007	-0.010	-0.001	-0.001
	(0.045)	(0.047)	(0.005)	(0.008)	(0.002)	(0.003)
lag of financial risk index	-0.043	-0.051	-0.009**	-0.017**	0.003	0.002
	(0.038)	(0.040)	(0.004)	(0.008)	(0.002)	(0.003)
lag of political risk index	-0.019	-0.002	-0.005	-0.003	0.001	0.001
	(0.040)	(0.042)	(0.004)	(0.007)	(0.002)	(0.003)
time effects	yes	yes	yes	yes	yes	yes
country effects	yes	yes	yes	yes	yes	yes
Constant	-62.138***	-57.881**	-4.685***	-8.027**	0.499	0.561
	(21.660)	(25.941)	(1.533)	(3.146)	(0.654)	(1.286)
Observations	1309	903	1923	961	1923	961
R-squared			0.24	0.26	0.04	0.05

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: Step 2: Effect of uncertainty in B on crisis there, all initial crises countries

Panel regressions of crisis in potentially affected country on the lagged uncertainty in B

Step 2 Effect of uncertainty in a country on the probability of a crisis there if a crisis takes place in an initial crisis country
Dependent Variable crisis as measured by significant negative returns in country B at t
The considered crises periods are Mexico 1994/5, Thailand 1997, Russia 1998, Brazil 1999, Turkey 2001, Argentina 2002

	(1)	(2)	(3)	(4)	(5)	(6)
					returns as dep. Variable	
	pooled probit all crises, all countries	pooled probit all crises, emerging markets	linear probability all crises, all countries	linear probability all crises, emerging markets	OLS, all crises, all countries	OLS, all crises, emerging markets
lag of interact. uncert. in B & crisis in Mex, Rus, Tha	0.286***	0.314***	0.092***	0.071***	-0.013***	-0.010*
	(0.078)	(0.082)	(0.010)	(0.015)	(0.004)	(0.006)
lag of interact. com creditors & crisis in A	5.556*	5.136	0.152**	1.605**	-0.003	-0.220
	(2.865)	(3.424)	(0.075)	(0.642)	(0.032)	(0.264)
lag of interact. tradeshare & crisis in A	5.779**	5.867**	1.234***	1.132***	-0.380***	-0.408**
	(2.536)	(2.602)	(0.264)	(0.405)	(0.113)	(0.167)
lag of interact. market size & crisis in A	-0.000	-0.000	-0.000	-0.000	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
lag of mean growth expectation	0.149***	0.139***	0.011***	0.013**	-0.011***	-0.012***
	(0.040)	(0.043)	(0.004)	(0.006)	(0.002)	(0.003)
lag of stockmarket volatility	11.193**	8.918*	2.009***	1.179*	-0.343*	-0.291
	(4.390)	(4.615)	(0.481)	(0.678)	(0.207)	(0.279)
lag of economic risk index	-0.049	-0.061	-0.004	-0.007	-0.001	-0.001
	(0.045)	(0.047)	(0.005)	(0.008)	(0.002)	(0.003)
lag of financial risk index	-0.043	-0.052	-0.008*	-0.017**	0.002	0.002
	(0.038)	(0.040)	(0.004)	(0.008)	(0.002)	(0.003)
lag of political risk index	-0.010	0.009	-0.004	-0.001	0.001	0.001
	(0.040)	(0.042)	(0.004)	(0.007)	(0.002)	(0.003)
time effects	yes	yes	yes	yes	yes	yes
country effects	yes	yes	yes	yes	yes	yes
Constant	-61.549***	-57.002**	-3.606**	-7.253**	0.521	0.837
	(21.754)	(26.069)	(1.509)	(3.079)	(0.649)	(1.267)
Observations	1309	903	1923	961	1923	961
R-squared			0.25	0.27	0.04	0.05

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

Table 9: Step 2: Effect of uncertainty in B on crisis there, Mexican, Russian and Thai crises

Panel regressions of crisis in potentially affected country on the lagged uncertainty in B

Step 2 Effect of uncertainty in a country on the probability of a crisis there if a crisis takes place in an initial crisis country

Dependent Variable crisis as measured by significant negative returns in country B at t

The considered crises periods are Mexico 1994/5, Thailand 1997, Russia 1998, Brazil 1999, Turkey 2001, Argentina 2002

	(1)	(2)	(3)	(4)	(5)	(6)
	pooled probit all crises, emerging markets	linear probability all crises, emerging markets	OLS, all crises, emerging markets	pooled probit all crises, emerging markets	linear probability all crises, emerging markets	OLS, all crises, emerging markets
lag of interact. uncert. in B & crisis in all initial crisis cntrs.	0.109**	0.029**	0.003			
	(0.055)	(0.012)	(0.005)			
lag of interact. uncert. in B & crisis in Mex, Rus, Tha				0.281***	0.074***	-0.018**
				(0.096)	(0.020)	(0.008)
lag of interact. com creditors & crisis in A	2.976	0.506	-0.147	3.384	0.569	0.060
	(4.459)	(0.985)	(0.392)	(4.385)	(0.953)	(0.381)
lag of interact. tradeshare & crisis in A	5.715	1.540	-0.510	3.397	1.063	-0.509
	(5.363)	(1.135)	(0.452)	(5.343)	(1.119)	(0.447)
lag of interact. market size & crisis in A	-0.000	-0.000	0.000*	-0.000	-0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
lag of interact. overexp. index & crisis in A	0.013**	0.002**	-0.000	0.012**	0.002*	-0.000
	(0.006)	(0.001)	(0.000)	(0.006)	(0.001)	(0.000)
lag of mean growth expectation	0.194***	0.029***	-0.018***	0.220***	0.033***	-0.023***
	(0.056)	(0.011)	(0.004)	(0.056)	(0.010)	(0.004)
lag of stockmarket volatiltiy	5.682	1.663	-1.511***	8.524	2.117	-1.708***
	(6.159)	(1.308)	(0.521)	(6.426)	(1.308)	(0.522)
lag of economic risk index	-0.039	-0.006	-0.002	-0.023	-0.003	-0.003
	(0.058)	(0.011)	(0.004)	(0.057)	(0.010)	(0.004)
lag of financial risk index	-0.082*	-0.021**	0.003	-0.084*	-0.021**	0.002
	(0.046)	(0.009)	(0.004)	(0.046)	(0.009)	(0.004)
lag of political risk index	-0.044	-0.011	0.003	-0.033	-0.009	0.002
	(0.050)	(0.011)	(0.004)	(0.051)	(0.010)	(0.004)
time effects	yes	yes	yes	yes	yes	yes
country effects	yes	yes	yes	yes	yes	yes
Constant	-530.683***	-71.981***	12.395**	-501.949***	-65.410***	10.416**
	(94.537)	(12.951)	(5.158)	(95.941)	(13.010)	(5.198)
Observations	539	571	571	539	571	571
R-squared		0.28	0.10		0.29	0.10

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

Table 10: Step 2: Effect of uncertainty in B on crisis there, additional control for common overexposed fund investors

Panel regressions of crisis in potentially affected country on the lagged uncertainty in B

Step 2 Effect of uncertainty in a country on the probability of a crisis there if a crisis takes place in an initial crisis country

Dependent Variable crisis as measured by significant negative returns in country B at t

Data source: MSCI

The considered crises periods are Mexico 1994/5, Thailand 1997, Russia 1998, Brazil 1999, Turkey 2001, Argentina 2002

					returns as dep. Variable	
	(1)	(2)	(3)	(4)	(5)	(6)
	pooled probit all crises, all countries	pooled probit all crises, emerging markets	linear probability all crises, all countries	linear probability all crises, emerging markets	OLS, all crises, all countries	OLS, all crises, emerging markets
lag of uncertainty in B	0.292**	0.267*	0.061***	0.043**	0.005	0.011
	(0.134)	(0.140)	(0.013)	(0.019)	(0.006)	(0.008)
lag of mean of growth exp.	-0.026	-0.038	-0.007***	-0.008**	-0.004***	-0.003**
	(0.026)	(0.027)	(0.002)	(0.004)	(0.001)	(0.002)
lag of crisis in Arg	0.318**	0.272*	0.018*	0.028	-0.008*	-0.008
	(0.145)	(0.159)	(0.009)	(0.018)	(0.004)	(0.008)
lag of crisis in Bra	0.608***	0.650***	0.057***	0.116***	-0.021***	-0.026***
	(0.157)	(0.172)	(0.011)	(0.022)	(0.005)	(0.010)
lag of crisis in Rus	0.391*	0.555**	0.096***	0.191***	0.042***	0.037***
	(0.202)	(0.223)	(0.015)	(0.029)	(0.007)	(0.013)
lag of crisis in Tha	0.818***	0.869***	0.076***	0.131***	-0.032***	-0.055***
	(0.102)	(0.113)	(0.008)	(0.015)	(0.004)	(0.007)
lag of crisis in Tur	-0.059	0.026	0.004	0.016	-0.002	-0.001
	(0.130)	(0.141)	(0.008)	(0.016)	(0.004)	(0.007)
country effects	yes	yes	yes	yes	yes	yes
Constant	-2.741***	-1.714***	-0.032	-0.009	0.028***	0.027*
	(0.412)	(0.342)	(0.021)	(0.033)	(0.011)	(0.014)
Observations	2828	1630	4016	1947	4113	1946
R-squared			0.15	0.20	0.03	0.05

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

Table 11: Step 2: Effect of uncertainty in B on crisis there, robustness check

Marginal effects of probit regressions of crisis in potentially affected country on the lagged uncertainty

Step 2 Effect of uncertainty in a country on the probability of a crisis there if a crisis takes place in an initial crisis country

Dependent Variable crisis as measured by significant negative returns in country B at t

Data source: MSCI

The considered crises periods are Mexico 1994/5, Thailand 1997, Russia 1998, Brazil 1999, Turkey 2001, Argentina 2002

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	all countries	emerging markets	all countries	emerging markets	all countries	emerging markets	all countries	emerging markets
lag of interact. uncert. in B &	0.025***	0.039***			0.042**	0.052***		
crisis in Mex, Rus, Tha	(0.007)	(0.011)			(0.017)	(0.019)		
lag of interact. uncert. in B &			0.009**	0.016**			0.016	0.020*
crisis in all initial crisis cntrs.			(0.004)	(0.007)			(0.010)	(0.010)
lag of interact. com creditors &	0.481*	0.637	0.511*	0.626	0.301	0.629	0.255	0.550
crisis in A	(0.263)	(0.431)	(0.274)	(0.445)	(0.773)	(0.818)	(0.785)	(0.827)
lag of interact. tradeshare &	0.500**	0.728**	0.607***	0.907***	0.713	0.631	1.064	1.057
crisis in A	(0.224)	(0.326)	(0.229)	(0.334)	(0.956)	(0.988)	(0.955)	(0.986)
lag of interact. market size &	-0.000	-0.000	-0.000	-0.000	0.000	-0.000	0.000	-0.000
crisis in A	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
lag of interact. overexp. index					0.002**	0.002**	0.002**	0.002**
& crisis in A					(0.001)	(0.001)	(0.001)	(0.001)
lag of mean growth expectation	0.013***	0.017***	0.011***	0.015***	0.042***	0.041***	0.038***	0.036***
	(0.003)	(0.005)	(0.004)	(0.006)	(0.010)	(0.010)	(0.010)	(0.010)
lag of stockmarket volatility	0.968**	1.107*	0.862**	0.922	1.838	1.584	1.384	1.051
	(0.387)	(0.567)	(0.387)	(0.576)	(1.139)	(1.203)	(1.086)	(1.144)
lag of economic risk index	-0.004	-0.008	-0.006	-0.010	-0.002	-0.004	-0.005	-0.007
	(0.004)	(0.006)	(0.004)	(0.006)	(0.010)	(0.011)	(0.010)	(0.011)
lag of financial risk index	-0.004	-0.006	-0.004	-0.006	-0.014*	-0.016*	-0.014*	-0.015*
	(0.003)	(0.005)	(0.003)	(0.005)	(0.008)	(0.009)	(0.008)	(0.009)
lag of political risk index	-0.001	0.001	-0.002	-0.000	-0.009	-0.006	-0.010	-0.008
	(0.003)	(0.005)	(0.004)	(0.005)	(0.009)	(0.009)	(0.009)	(0.009)
time effects	yes	yes	yes	yes	yes	yes	yes	yes
country effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1309	903	1309	903	586	539	586	539

Standard errors in parentheses, * significant at 10%; ** significant at 5%; *** significant at 1%

Table 12: Marginal effect of uncertainty in B on probability of a crisis there

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